Electron-Capture Delayed Fission of ^{242}Es

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We previously reported evidence that ^{242}Es undergoes electron-capture delayed fission (ECDF.)[1] We have performed additional experiments in order to determine the decay properties of ^{242}Es and its probability of delayed fission (P_{DF}.)

The ^{242}Es was produced at the LBNL 88-Inch Cyclotron via the ^{233}U(^{14}N, 5n)^{242}Es reaction. To prepare the target ^{233}U was placed on an anion exchange column and washed several times with concentrated HCl to remove lead impurities. The target material was eluted from the column with dilute HCl and electroplated on Be foil. Reaction products from the cyclotron were transported via a He/KCl aerosol gas-jet through a capillary to our MG rotating wheel detection system. The aerosols were deposited consecutively on 80 thin polypropylene foils located on the periphery of the wheel which was moved every 10 seconds between six pairs of Si(Au) surface barrier detectors.

^{242}Es is reported to decay with a 7.9 MeV alpha particle and a half-life of 16^{+0}_{-4} seconds.[2] We looked for alpha particles coming from ^{242}Es, as well as its EC daughter, ^{242}Cf. The ^{242}Es branching ratio and initial EC activity could be determined by comparing the production of ^{242}Cf to that of ^{242}Es. Once the initial EC activity is measured, the P_{DF} is calculated by comparing the number of fission events to the total number of EC decays.

Even though most of the lead was removed from the ^{233}U target, a large amount of ^{213}Fr was made. Fr is produced when lead is bombarded with nitrogen. This huge peak in the spectra obscured the much smaller ^{242}Cf peak at 7.385 MeV making the EC branching ratio impossible to determine. This in turn prevented us from measuring the P_{DF}.

Another problem we encountered was the production of ^{243}Es at 7.895 MeV. We ran the ^{14}N at a higher energy than before (91 MeV on target) to try and suppress ^{243}Es production, but enough

was made to interfere with the ^{242}Es peak at 7.9 MeV. When this entire region was integrated, it was found to decay with a half-life of 35 seconds. This is longer than that of ^{243}Es (21 seconds) which indicates that the region was probably a combination of both ^{242}Es and ^{243}Es. Unfortunately our system could not resolve the two into separate peaks.

We saw 16 coincident fissions with a half-life of 25 ± 2 seconds. Since the fissions decay with the half-life of the EC parent, this would also be the half-life of ^{242}Es. This is slightly longer than previously reported. The fission fragments had an asymmetric mass distribution and a pre-neutron average total kinetic energy (TKE) of 199 ± 21 MeV. This is 6 to 13 MeV higher than semi-empirical fits predict for ^{242}Cf.[3]

Based on the fission half-life, the fission events could not have come from a different Es isotope. Also, the P_{DF} has been shown to increase sharply with increasing electron-capture Q-value (Q_{EC}.)[4] The Q_{EC} of ^{242}Es is greater than all other Es isotopes by at least 1 MeV making it the most probable delayed fission precursor. The Q_{EC} of its neighboring isotopes would correspond to a P_{DF} too small to account for 16 fissions over the whole experiment, implying that the ECDF was from ^{242}Es.

Footnotes and References

1. Nuclear Science Division Annual Report, LBL-37384 (1994.)
2. V. Ninov, private communication (1997.)
3. D.C. Hoffman and M.R. Lane, *Radiochimica Acta*, 70/71, 135 (1995).
4. S.A. Kreek *et al.*, *Phys. Rev. C* 50, 2288 (1994).